PETROGRAPHICAL TABLES

AN AID TO THE

Microscopical Determination

OF

ROCK-FORMING MINERALS

ROSENBUSCH—HATCH

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OF

ROCK-FORMING MINERALS

BY

PROFESSOR H. ROSENBUSCH

TRANSLATED AND EDITED (WITH THE AUTHOR'S PERMISSION)

BY

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INTRODUCTION.

IN preparing an English edition of PROFESSOR ROSENBUSCH's *Hülfstabellen zur mikroskopischen Mineralbestimmung in Gesteinen*, I have made a slight alteration in the order of the columns, and added an Index, which, I think, will facilitate reference: in all other respects the original arrangement remains unchanged.

Some explanation of the signs and symbols used in the tables is perhaps necessary. The letters *a*, *b*, *c*, represent the crystallographic axes: *a* and *b* being the lateral axes, and *c* the vertical. The axes of the ellipsoid of elasticity are denoted by the Old English letters $\mathfrak{a}$, $\mathfrak{b}$, $\mathfrak{c}$: $\mathfrak{a}$ being the axis of greatest elasticity, $\mathfrak{b}$, the axis of mean elasticity, and $\mathfrak{c}$, the axis of least elasticity. The Greek letters α, β, γ, have sometimes been used to denote the axes of elasticity; but, as the practice is not uniform, and as the Greek letters, moreover, have been adopted by PROFESSOR ROSENBUSCH (and indeed are used invariably in Germany) for the chief indices of refraction in biaxial crystals, I have thought it best to leave the symbols unchanged. After all, the symbols themselves are of little moment, so long as the meaning attaching to them is made clear.

The three chief indices of refraction in biaxial crystals are then as follows:

α = index of refraction for rays vibrating parallel to $\mathfrak{a}$, but transmitted in a direction normal to $\mathfrak{a}$.

β = index of refraction for rays vibrating parallel to $\mathfrak{b}$, but transmitted in a direction normal to $\mathfrak{b}$

γ = index of refraction for rays vibrating parallel to $\mathfrak{c}$, but transmitted in a direction normal to $\mathfrak{c}$.

The mean index of refraction is $n = \frac{\alpha + \beta + \gamma}{3}$.

2 E denotes the apparent optic axial angle, or angle between the optic axes measured in air.

The expression $\rho < \upsilon$ (under the head of dispersion) indicates that the optic axial angle for red rays is smaller than that for violet; $\rho > \upsilon$ that it is greater.*

While the book was passing through the press some additional data with reference to the minerals monazite and mosandrite have been kindly furnished by PROFESSOR ROSENBUSCH. These data were determined in his laboratory on monazite from Arendal, and mosandrite from Lôven, Langesundfjord.

F. F. H.

* In addition to the above symbols, the ordinary mathematical signs are used as abbreviations. These are: =, the sign of equality, used in the column headed "Optic Orientation" to express the coincidence of an axis of elasticity with a crystallographic axis; V, greater than; <, less than; $\perp$, perpendicular to; $\parallel$, parallel to; $\sphericalangle$, angle; +, positive; − negative.

INDEX.

	Name.	System.	Cleavage. Quality.	Cleavage. Direction.	Cleavage. Angle.	Characteristic Form.	Opt. Char. of the Mineral.	Principal Zone or Face.	Forms Of Principal Zone.	Opt. Char.	Colour.
	Glass . . .	amorphous	...	...	...	...	...	...	...	...	colourless, yellowish, greenish, brownish, red
	Opal	amorphous	...	...	...	...	...	...	...	...	colourless
Spinellids.	Spinel . .	regular	...	...	...	(111), grains	...	...	...	...	colourless, light red
	Pleonaste.	regular	...	...	...	(111), grains	...	...	...	...	green
	Hercynite	regular	...	...	...	(111), grains	...	...	...	...	green
	Gahnite .	regular	...	...	...	(111), grains	...	...	...	...	green
	Picotite .	regular	...	...	...	(111)	...	...	...	...	brown
	Chromite.	regular	...	...	...	(111), grains	...	...	...	...	brown
	Fluorite . .	regular	good	111	...	(100), grains	...	...	...	...	colourless, violet, etc.
Garnets.	Grossularia	regular	bad	110	...	(110), grains	...	...	...	...	colourless, pale-green
	Almandine	regular	bad	110	...	(110), (211), grs.	...	...	...	...	red
	Melanite .	regular	bad	110	...	(110), (110)(211), grains	...	...	...	...	brown
	Spessartine	regular	bad	110	...	(110), grains	...	...	...	...	colourless, light-reddish
	Pyrope. .	regular	bad	110	...	grains	...	...	...	...	blood-red
	Uwarowite	regular	bad	110	...	(110)	...	...	...	...	green
	Common Garnet .	regular	bad	110	...	(110), grains	...	...	...	...	reddish
	Leucite. . .	regular	...	...	...	(211), round grs.	...	...	...	...	colourless
	Sodalite . .	regular	fair	110	...	(110), grains	...	...	...	...	colourless, blue, green, yellow, etc.
	Nosean. . .	regular	fair	110	...	(110)	...	...	...	...	
	Hauyne . .	regular	fair	110	...	(110), grains	...	...	...	...	
Zeolites.	Analcime.	regular	fair	100	...	(211), (211) (100), grains	...	...	...	...	colourless
	Faujasite .	regular	fair	111	...	(111)	...	...	...	...	colourless
	Perofskite .	regular	...	...	...	(111) (100), grs.	...	...	...	...	greyish brown, pale violet, brownish yellow

roism.	Index of Refraction (n) and Double Refraction.				Optic Orientation.	2 E	Dispersion.	Specific Gravity.	Behaviour with Reagents.	Chemical Composition.	Remarks.
	$n=\frac{\alpha+\beta+\gamma}{3}$	$\gamma-\alpha$	$\beta-\alpha$	$\gamma-\beta$							
..	very small 1·481—1·495 in Obsidian	...	...	...	...	...	...	2·2—2·7	variable		
.	1·45	...	...	...	...	...	...	2·2	soluble in HKO	$SiO_2 + x\ aq$	Occasional weak irregular double refraction.
..	1·715	...	...	...	...	...	...	3·6—4·5	insol. in acids	$MgAl_2O_4$	Not decomp. by fus. with Na_2CO_3
..	...	...	...	...	...	...	...	> 3·65	Ditto	$(MgFe)(Al_2Fe_2)O_4$	Ditto
..	1·749	...	...	...	...	...	...	3·94	Ditto	$FeAl_2O_4$	Ditto
..	1·765	...	...	...	...	...	...	4·35	Ditto	$ZnAl_2O_4$	Ditto
..	...	...	...	...	...	...	...	4·08	Ditto	$(FeMg)(Al_2Cr_2Fe_2)O_4$	Ditto
..	2·096	...	...	...	...	...	...	4·8	Ditto	$FeCr_2O_4$	Ditto
..	1·433	...	...	...	...	...	...	3·18—3·2	insol. in HCl	$CaFl_2$	Gives off HF when treated with sulphuric acid. Loses colour on ignition. Occasional weak double refraction.
..	1·747	...	...	...	...	...	...	3·4—3·6	insol. in acids	$Ca_3Al_2Si_3O_{12}$	Scarcely decomposed by fusion with Na_2CO_3. Occasional anomalous double refraction. Easily fusible.
..	1·770	...	...	...	...	...	...	4·1—4·3	Ditto	$Fe_3Al_2Si_3O_{12}$	Zonal structure not uncommon.
..	1·784	...	...	...	...	...	...	3·65—4·3	Ditto	$Ca_3Fe_2Si_3O_{12}$	Zonal structure very common. Easily fusible.
..	...	...	...	...	...	...	...	3·7—4·27	Ditto	$Mn_3Al_2Si_3O_{12}$	Fusible with difficulty. Kelyphite-structure.
..	1·812	...	...	...	...	...	...	3·7—3·8	Ditto	$Mg_3Al_2Si_3O_{12}$	
..	...	...	...	...	...	...	...	3·4—3·51	Ditto	$Ca_3Cr_2Si_3O_{12}$	
..	...	...	...	...	...	...	...	3·4—4·3	Ditto	mixtures of the above molecules	
..	1·508	...	...	...	...	...	...	2·42—2·5	attacked slowly by HCl, with separation of pulverulent SiO_2	$(KNa)_2Al_2Si_4O_{12}$	The large individuals always doubly refracting with intersecting systems of twin-lamellæ. Weak double refraction = 0·001.
..	1·484	...	...	...	...	...	...	2·28—2·34	gelatinizes easily with HCl	$2(Na_2Al_2Si_2O_8) + NaCl$	Occasional abnormal double refraction.
..	...	...	...	...	...	...	...	2·27—2·50	Ditto	$2(Na_2Al_2Si_2O_8) + Na_2SO_4$	Marginal or zonal accumulation of Inclusions. In the gelatine produced by HCl; few or no needles of gypsum (= noscan).
..	1·496	...	...	...	...	...	...			$2(CaAl_2Si_2O_8) + CaSO_4$	Numerous needles of gypsum (= haüyne).
..	1·488	...	...	...	...	...	...	2·15—2·28	gelatinizes with HCl	$Na_2Al_2Si_4O_{12} + 2\ aq$	Often optically enomalous with weak double refraction.
..	...	...	...	...	...	...	...	1·923	soluble in HCl	$H_4Na_2CaAl_4Si_{10}O_{30} + 18\ aq$	Frequent anomalous double refraction.
..	2·38	...	...	...	...	...	...	4·1	soluble in hot sulphuric acid	$CaTiO_3$	The larger individuals mostly optically anomalous with twin-lamellation.

Name.	System.	Cleavage.			Characteristic Form.	Opt. Char. of the Minerals.	Principal Zone or Face.	Forms of the Principal Zone.	Opt. Char.	Colour.
		Quality.	Direction.	Angle.						
Rutile . . .	tetrag.	good fair	110 100	90° 90°	prisms, grains knee & heart-shaped twins sagenite-texture	+	110:1$\bar{1}$0	prismatic	+	yellow, fox-red, violet
Cassiterite .	tetrag.	fair	100	90°	grains, rods, prisms, twins	+	110:1$\bar{1}$0	prismatic	+	colourless, yellowish brownish
Zirkon . . .	tetrag.	good fair	110 100	90° 90°	prisms, pyramids rare	+	110:1$\bar{1}$0	prismatic	+	colourless, yellowish reddish
Anatase . .	tetrag.	good good	001 111	 136½°	pyramidal tabular	−	001	...	+	colourless, yellowish bluish
Micaceous Hæmatite (Eisenglimmer) . . .	hex. rhombohedr.	...	...	...	scales	...	0001	...	...	red, yellow, grey
Micaceous Ilmenite (Titaneisenglimmer) .	hex. rhombohedr.	...	...	...	scales	...	0001	...	...	madder or clove-brown
Corundum .	hex. rhombohedr.	...	...	...	prisms, grains, plates	−	...	...	...	colourless, blue
Quartz . . .	hex. rhombohedr. (trapez. tetart.)	...	...	...	grains, blebs, doubly-terminated pyramids	+	...	...	...	colourless
Chalcedony .	hexag. (?)	...	...	...	fibrous	−	10$\bar{1}$0:01$\bar{1}$0	fibrous	−	colourless, yellowish
Tridymite . .	hexag. (?)	...	...	...	minute plates	+	0001	...	...	colourless
Brucite . .	hex. rhombohedr.	good	0001	...	scales	+	0001	lath-shaped	−	colourless
Spars. Calcite. .	hex. rhombohedr.	good	κ(10$\bar{1}$1)	105°5′	grains	−	...	...	...	colourless
Spars. Dolomite .	hex. rhombohedr.	good	κ(10$\bar{1}$1)	106°15′	rhombohedra, grains	−	...	...	...	colourless, yellowish
Spars. Magnesite	hex. rhombohedr.	good	κ(10$\bar{1}$1)	107°25′	rhombohedra, grains	−	...	...	...	colourless
Apatite . . .	hexag. (pyr. hem).	bad	0001 10$\bar{1}$0	...	prisms, grains	−	10$\bar{1}$0:01$\bar{1}$0	lath-shaped	−	colourless, bluish, brownish
Scapolites. Meionite .	tetrag.	good fair	100 110	90°	rods, prisms, grains	−	110:1$\bar{1}$0	lath-shaped	−	colourless
Scapolites. Dipyre. .	tetrag.	good fair	100 110	90°	rods, prisms, grains	−	110:1$\bar{1}$0	lath-shaped	−	colourless
Scapolites. Couseranite . .	tetrag.	good fair	100 110	90°	rods, prisms, grains	−	110:1$\bar{1}$0	lath-shaped	−	colourless
Gehlenite . .	tetrag.	fair	001 110	...	isometric	−	...	...	...	colourless

TING UNIAXIAL MINERALS.

chroism.	Index of Refraction (n) and Double Refraction.				Optic Orientation.	2 E	Dispersion.	Specific Gravity.	Behaviour with Reagents.	Chemical Composition.	Remarks.
	$n=\frac{\alpha+\beta+\gamma}{3}$	$\gamma-\alpha$	$\beta-\alpha$	$\gamma-\beta$							
erceptible w to yellowish-grey	2·759	0·287	...	...	c = c	...	...	4·2—4·25	not attacked by HCl or HF	TiO_2	The fusion with (or solution in) $K_2S_2O_7$ is coloured orange by H_2O_2.
...	2·019	0·107	...	...	c = c	...	...	6·87	like Rutile	SnO_2	A borax bead, coloured blue with copper sulphate, becomes ruby-red.
...	1·987	0·060	...	...	c = c	...	...	4·4—4·7	like Rutile	$ZrSiO_4$	Fused with Na_2Co_3 gives tridymite-like tablets of ZrO_2.
blue, orange blue; pale yellow, ɔm perceptible	2·524	0·061	...	...	c = a	...	...	3·9	like Rutile	TiO_2	Like Rutile.
...	1·93	...	...	...	?	...	...	4·5—5·3	soluble in HCl	Fe_2O_3	
...	...	...	...	...	?	...	...	4·3—4·9	soluble in HCl with difficulty	$FeTiO_3$	
ne ı-green	1·764	0·009	...	...	c = a	...	...	3·9—4·0	insoluble in acids	Al_2O_3	Twinning parallel to R; not decomposed by fusion with Na_2Co_3.
...	1·551	0·009	...	...	c = c	...	...	2·65	soluble in HFl only	SiO_2	...
...	1·537	>0·009	...	...	c = a	...	...	2·59—2·64	like Quartz	SiO_2	...
...	1·428	0·018?	...	...	c = c	...	...	2·28—2·33	soluble in alkalies	SiO_2	The plates often divided into six biaxial sectors.
...	1·570	0·021	...	...	c = c	...	...	2·35	soluble in acids	MgH_2O_2	Becomes brownish, when moistened with silver-nitrate on platinum-foil.
...	1·601	0·172	...	...	c = a	...	...	2·72	soluble in acetic acid with effervescence	$CaCO_3$	Twinning parallel to κ $(10\bar{1}2)$, very common.
...	1·622	0·179	...	...	c = a	...	...	2·85—2·95	insoluble in acetic acid	$CaCO_3+MgCo_3$	Twinning parallel to κ $(10\bar{1}2)$, not observed.
...	...	...	...	...	c = a	...	...	3·0	insoluble in cold HCl	$MgCO_3$	Twinning parallel to κ $(10\bar{1}2)$, not observed.
> 0	1·637	0·004	...	...	c = a	...	...	3·16—3·22	easily soluble in acids	$3(Ca_3P_2O_8)+Ca(ClFl)_2$	Reaction for phosphoric acid with ammonium molybdate in nitric acid solution.
...	1·578 1·550	0·036 0·015	...	...	c = a	...	...	2·74 2·57	soluble in HCl when rich in Ca: insoluble when poor in Ca	Mixtures of: $Me=Si_{12}Al_{12}Ca_8O_{50}$ $Ma=Si_{12}Al_6Na_8O_{48}Cl_2$	Index of refraction, double refraction and specific weight vary with the percentage of lime.
..	1·660	0·005	...	...	c = a	...	...	2·95—3·0	gelatinizes with HCl	$Ca_3Al_2Si_2O_{10}$	...

Name.	System.	Cleavage.			Characteristic Form.	Opt. Char. of the Mineral.	Principal Zone or Face.	Forms of the Principal Zone.	Opt. Char.	Colour.	P
		Quality.	Direction.	Angle.							
Idocrase (Vesuvian) .	tetrag.	...	...	...	isometric	—	...	...	...	colourless, yellowish, pink, brownish, bluish	
Melilite . .	tetrag.	fair	001	...	tablets, short prisms	—	001 110 : 1$\bar{1}$0	lath-shaped, almost square	±	colourless to yellowish	
Nepheline (Elæolite)	hexag.	bad	0001 10$\bar{1}$0	...	short prisms, grains	—	...	...	...	colourless	
Cancrinite .	hexag.	good	10$\bar{1}$0	120°	long prisms, rods	—	10$\bar{1}$0 : 01$\bar{1}$0	lath-shaped	—	colourless	
Tourmaline .	hex. rhombohedr.	...	...	...	prisms, grains	—	10$\bar{1}$0 : 01$\bar{1}$0	lath-shaped	—	very variable : violet, blue, green	stro
Eudialyte . .	hex. rhombohedr.	fair	0001	...	isometric	+	...	...	...	reddish, colourless	
Eucolite . .	hex. rhombohedr.	fair	0001	...	isometric	—	...	...	...	reddish, colourless	
Cataplëite .	hexag.	good	10$\bar{1}$0	120°	tabular	+	0001	lath-shaped	—	yellowish, colourless	
Melinophane.	tetrag.	good	001	...	tabular	—	001	lath-shaped	+	pale yellowish, colourless	
Zeolites. Apophyllite . .	tetrag.	good	001	...	leafy, granular	∓	...	...	...	colourless	
Chabasite	hex. rhombohedr.	good	κ(10$\bar{1}$1)	86°	isometric	—	...	...	...	colourless	
Hydronepheline	hexag. (?) tetrag. (?)	...	...	...	grains, short rods	...	...	...	...	colourless	
Gismondine . .	tetrag.	...	...	...	...	+	...	...	...	colourless	
Gmelinite	hex. rhombohedr.	fair	10$\bar{1}$0	...	rhombohedra, plates	±	...	...	...	colourless	
Herschelite . .	hexag.	good	0001	...	tabular	—	...	lath-shaped	+	colourless	
Levyne .	hex. rhombohedr.	bad	10$\bar{1}$1	...	...	—	...	...	+	colourless	

roism.	Index of Refraction (n) and Double Refraction.				Optic Orientation.	2 E	Dispersion.	Specific Gravity.	Behaviour with Reagents.	Chemical Composition.	Remarks.
	$n=\frac{\alpha+\beta+\gamma}{3}$	$\gamma-\alpha$	$\beta-\alpha$	$\gamma-\beta$							
.	1·726	0·002	...	...	c = a	...	...	3·40—3·47	not attacked by HCl	essentially a lime-alumina silicate	Melts easily to a glass. Frequent optic anomalies. Double refraction very variable, sometimes even +.
.	1·629	0·002	...	...	c = a	...	...	2·9—2·95	gelatinizes easily with HCl	$(CaMgFe)_{12}Al_4Si_9O_{36}$	Peg-structure.
.	1·54	0·004	...	...	c = a	...	...	2·55—2·61	gelatinizes with HCl	$Na_2Al_2Si_2O_8$	The gelatine produced by treatment with HCl contains cubes of salt.
.	1·515	0·030	...	...	c = a	...	...	2·45	dissolves with effervescence in HCl	$Na_2Al_2Si_2O_8 + 2(CaCO_3) + 3H_2O$	...
> E	1·635	0·023	...	...	c = a	...	...	3·0—3·24	not attacked by acids	isomorphous mixtures of: $NaHOB_2O_3 3Al_2O_3 4SiO_2$, $5MgOB_2O_3Al_2O_3 5SiO_2$, $5FeOB_2O_3Al_2O_3 5SiO_2$	Often apparently biaxial, with small optic axial angle.
	...	...	...	...	c = c	...	...	2·95—3·0	gelatinizes with HCl	$Na_2(CaFe)_2(SiZr)_6O_{15}$	...
	1·620	0·004	...	...	c = a	...	...	2·85—2·94	Ditto	$Na_2(CaFe)_2(SiZr)_6O_{15}$	...
	1·612	0·030	...	...	c = c	...	...	2·8	gelatinizes with HCl	$(Na_2CaFe)(SiZr)_4O_9 + 2$ aq	Often apparently biaxial.
	1·602	0·019	...	...	c = a	...	...	3·0	...	$6NaF + 7[(BeCa)_3Si_2O_7]$	Often apparently biaxial.
	1·532	0·001	...	...	c = a or c	...	...	2·35—2·39	dissolves in HCl with separation of pulverulent SiO_2	$4H_2CaSi_2O_6 + KF + aq.$	Often optically anomalous.
	1·50	0·003	...	...	c = a	...	...	2·15	decomposed by HCl with separation of flocculent SiO_2	$Ca_2Al_4Si_9O_{26} + 14aq.$	Frequent twin-lamellation.
	1·47 (?)	...	...	...	...	...	...	2·26	decomposed by HCl	$Na_4H_2Al_6Si_6O_{24} + 6aq.$	...
	1·52	0·008	...	...	...	...	...	2·265	gelatinizes with HCl	$CaAl_2Si_2O_8 + 4aq.$	Invariable separation between crossed nicols into several biaxial areas, in which 2 E = 558 (approximately).
	1·48	0·001	...	...	...	...	...	2·04—2·12	gelatinizes with HCl	$(Na_2Ca)Al_2Si_4O_{12} + 6aq.$	Often optically anomalous.
	1·46	0·002	...	...	...	...	...	2·06	decomposed by HCl	$(Na_2K_2Ca)Al_2Si_4O_{12} + 5aq.$	Basal sections shew a separation into 6 sectors.
	1·50	0·002	...	...	...	...	...	2·1—2·2	...	$CaAl_2Si_3O_{10} + 5aq.$	Frequent separation into 6 sectors in basal section.

Name.	System.	Cleavage.			Characteristic Form.	Opt. Char. of the Mineral.	Principal Zone or Face.	Forms of Principal Zone.	Opt. Char.	Colour.	Pleochroism.
		Quality.	Direction.	Angle.							
Brookite .	rhombic	good	010	...	plates	+	100	narrow lathes	—	fox-red	feeble
Pseudo-brookite .	rhombic	...	...	...	plates	+	100	narrow lathes	—	fox-red	feeble
Aragonite .	rhombic	...	...	...	columnar	—	100—010	lath-shaped	—	colourless	...
Anhydrite .	rhombic	good	010 001 100	...	isometric	+	...	...	...	colourless	...
Gypsum (Selenite)	monoclinic	good fair	010 11$\bar{1}$ 100	...	leafy, granular	+	...	...	...	colourless	...
Monazite .	monoclinic	good fair	001 100	...	thick tablets	+	...	...	...	pale brown	...
Lazulite .	monoclinic	...	...	...	grains, pyramids	—	...	...	...	blue	a colourless, b = blue
Andalusite (Chiastolite)	rhombic	good	110	91°	columnar,granular	—	110 : 1$\bar{1}$0	lath-shaped	—	colourless	c pink, a = colourless
Sillimanite	rhombic	good	100	...	columnar, acicular	+	100 : 010	long lathes	+	colourless	
Kyanite (Disthene)	triclinic	good fair	100 010	...	columnar, leafy	—	100 : 010	lath-shaped	+	colourless, blue	feeble, betwe bluish & colourl
Topaz . .	rhombic	good	001	...	isometric	+	...	...	...	colourless	...
Dumortierite	rhombic	fair	110	120°	acicular, fibrous	—	110 : 1$\bar{1}$0	long lathes	—	blue	c blue, a = b yellowish to colourl
Staurolite .	rhombic	fair	010	...	short columnar	+	110 : 1$\bar{1}$0	lath-shaped	+	yellow, reddish	c red, a = b yellowish
Sapphirine	monoclinic	good fair	010 100 110	80°	grains, plates parallel to 010	—	...	...	...	pale blue to colourless	a pale blue, c = colourless
Carpholite	monoclinic(?) rhombic (?)	...	...	...	acicular, fibrous	...	110 : 1$\bar{1}$0	rod-shaped lath-shaped	+	yellowish, colourless	c colourless, a = straw-yellow, yellowish green
Axinite . .	triclinic	fair	010	...	grains, plates	—	...	...	...	colourless	...

Index of Refraction (n) and Double Refraction.				Optic Orientation.	2 E	Dispersion.	Specific Gravity.	Behaviour with Reagents.	Chemical Composition.	Remarks.
$n=\frac{\alpha+\beta+\gamma}{3}$	$\gamma-\alpha$	$\beta-\alpha$	$\gamma-\beta$							
2·53	very high	...	...	a = t, c = a or a = t, b = a	>90° 46°	$\rho < v$ $\rho > v$	3·8—4·15	insoluble in acids	TiO_2	The optic axial plane for yellow and red often lies in 001, that for blue in 010.
very high	very high	...	...	a = t, b = a	84°30½′ (2 H)	$\rho < v$	4·98	insoluble in HCl	46—47%TiO_2, 48% to 49%Fe_2O_3, 4—5%MgO	Soluble in sulphuric acid on boiling.
1·631	0·156	0·153	0·004	c = a, b = t	30°	$\rho < v$	2·94	like Calcite	$CaCO_3$	...
1·587	0·043	0·005	0·038	a = t, c = a	71°	...	2·8—3	notably soluble in H_2O	$CaSO_4$	
1·524	0·009	0·002	0·007	b = b, c : t = 53° behind	95°	inclined	2·2—2·4	notably soluble in H_2O	$CaSO_4+2$ aq.	...
1·811	0·046	0·001	0·045	b = a, c : t = 3° in front	24°	horizontal $\rho < v$	49·—5·2	soluble in HCl	$(CeLa)_3P_2O_8$	Twinning parallel to 100.
1·625	0·036	0·029	0·007	b = b, c : a = 9½° behind	135°	inclined $\rho < v$	3—3·12	scarcely attacked by HCl	$(MgFe)Al_2P_2H_2O_{10}$	...
1·638	0·011	0·006	0·005	c = a, a = t	>180°		3·16—3·2	unattacked even by HFl	Al_2SiO_5	Frequent inclusions of carbonaceous matter.
1·667	0·021	0·002	0·019	c = t, b = a	40°	strong $\rho < v$	3·24	like Andalusite	Al_2SiO_5	...
1·720	0·016	0·008	0·008	a nearly ⊥ 100, t in 100 in the acute ∢ a 30° oblique to M : T	variable	$\rho < v$	3·5—3·7	like Andalusite	Al_2SiO_5	Gliding along 001. Twinning parallel to 100.
1·620	0·010	0·002	0·008	c = t, a = a	70°-120°	$\rho > v$	3·54,	like Andalusite	$5Al_2SiO_5+Al_2SiFl_{10}$	...
1·65	0·010	...	...	c = a, a = t	50°	$\rho < v$ (Bertrd.) $\rho > v$ (M. L.)	3·36	insoluble in acids	$Al_8Si_3O_{18}$	Twinning on the Aragonite-type.
·741—1·752	0·010—0·015	0·005	0·005	c = t, b = a	>180°	$\rho > v$	3·4—3·8	insoluble in acids	$FeAl_4Si_2O_{11}$	...
1·665	0·009	...	...	b = b	very large	$\rho < v$	3·4—3·5	insoluble in acids	$Mg_4Al_{10}Si_2O_{23}$	Twinning parallel to a face of the zone of the principal cleavage.
1·640	0·024	...	...	c = c	110°	...	2·93	insoluble in acids	$H_4MnAl_2Si_2O_{10}$	A measurement of the angle of extinction to c could not be carried out in Carpholite from Schlaggenwald. According to *Michel Levy* and *Lacroix* it is 5° in Carpholite from Wippra.
1·677	0·009	0·005	0.004	a ⊥ (111)	171°	horizontal and inclined	3·3	insoluble in acids	$H(CaFe)_3Al_2BSi_4O_{16}$	...

Name.	System.	Cleavage.			Characteristic Form.	Opt. Char. of the Mineral.	Principal Zone or Face.	Forms Of the Principal Zone.	Opt. Char.	Colour.	Pleochroism.
		Quality.	Direction.	Angle.							
Cordierite .	rhombic	bad	010	...	short columns, grains	−	...	...	...	colourless, blue	c yellowish white, b blue or colourles
Prehnite .	rhombic	good	001	...	leafy, tabular, granular	+	001	...	...	colourless	...
Datolite (Botryolite)	mono-clinic	...	...	...	isometric, fibrous	−	...	...	...	colourless	...
Homilite .	mono-clinic	...	...	...	variable, often short columns parallel to b or c	+	...	...	...	greenish	b > a > c
Gadolinite .	mono-clinic	...	...	...		+	...	...	...	bottle-green, brownish	...
Olivine . .	rhombic	fair	{010 {100	...	tables, short columns, grains	+	...	lath-shaped, isometric	...	colourless, greenish, yellowish	...
Fayalite .	rhombic	fair	{010 {100	...	ditto	...	...	ditto	...	colourless, reddish, yellowish	...
Humite . .	rhombic?	good	001	...	grains	+	...	isometric to elliptical	...	colourless to golden yellow	a pale brown, b c deep golden ye
Clinohumite and Chondrodite .	mono-clinic	good	001	...	ditto	+	...	ditto	...	ditto	ditto
Epidotes. Zoisite .	rhombic	{good {bad	010 100	...	short rods, leafy	+	100 : 010	lath-shaped	±	colourless	...
Thulite .	rhombic	{good {bad	001 100	...	ditto	+	ditto	ditto	±	reddish	c yellowish, b pi a reddish white
Pistacite	mono-clinic	{good {fair	001 100	115°24	rods, grains	−	001 : 100	ditto	±	colourless, yellowish, green	c green, b yellow green, a colour
Piedmontite, Withamite	mono-clinic	{good {fair	001 100	...	ditto	+	ditto	ditto	±	red, yellow	c red, b amethys coloured to pir a orange to cit yellow
Orthite (Allanite)	mono-clinic	{good {fair	001 100	...	columns, prisms	−	ditto	ditto	±	brown	c brownish yello b deep brown re a pale brownish g
Mosandrite	monoclinic	good	100	...	plates	+	100 : 010 001 : 100	short lathes	...	colourless to pale yellow	...
Rinkite . .	monoclinic	good	100	...	ditto	+	ditto	ditto	...	yellow to colourless	c yellowish, a= colourless

TING BIAXIAL MINERALS.

Index of Refraction (n) and Double Refraction.				Optic Orientation.	2 E	Dispersion.	Specific Gravity.	Behaviour with Reagents.	Chemical Compositions.	Remarks.
$n=\frac{\alpha+\beta+\gamma}{3}$	$\gamma-\alpha$	$\beta-\alpha$	$\gamma-\beta$							
1·542	0·009	0·006	0·003	c = a, b = c	64°–150	$\rho < v$	2·59—2·66	insoluble in HCl	$Mg_2Al_4Si_5O_{18}$	Twinning on the Aragonite type.
1·630	0·033	0·010	0·023	c = c, a = a	125°	$\rho < v$	2·8—3·0	insoluble in HCl	$H_2Ca_2Al_2Si_3O_{12}$	Occasionally intersecting systems of polysynthetic twin-lamellæ, with considerable change in the axial angle, double refraction and optic character.
1·650	0·044	0·028	0·016	b = b, c : a = 4° behind	176°	$\rho > v$	2·8—3·0	gelatinizes with HCl	$H_2Ca_2B_2Si_2O_{10}$	…
1·678	0·021	…	…	b = a, c : c nearly 0°	122°	$\rho > v$ horizontal	3·3	ditto	$FeCa_2B_2Si_2O_{10}$	Twins parallel to 001, also 034 and 021; often intergrown with yellow amorphous lamellæ.
>1·78	…	…	…	b = b, c : c = 3° behind	great	$\rho < v$	4—4·3	ditto	$FeBe_2Y_2Si_2O_{10}$	Often altered to an amorphous substance, then free from Be.
1·678	0·036	0·017	0·019	a = c, b = a	>180°	$\rho < v$	3·4	gelatinizes with HCl	$(MgFe)_2SiO_4$	Often altered to serpentine. Twins parallel to 011 rare.
…	0·043–0·049	…	…	…	…		4—4·14	ditto	Fe_2SiO_4	…
1·622	0·032—0·038	…	…	a = c, b = a	153°	$\rho < v$	3·06—3·23	soluble in HCl	$Mg_5Si_2(OF_2)_9$	Frequent polysynthetic twinning parallel to a face of the zone 001:010.
1·622	0·033	0·012	0·020	b = c, a : a = 12°—30° in front; above	ditto	crossed	ditto	ditto	ditto	Mostly polysynthetic twins parallel to 011.
1·696	0·006	0·001	0·005	a = c, c = a a = c, b = a	10°-100°	$\rho < v$ $\rho > v$	3·25—3·36	unattacked by HCl	$H_2Ca_4Al_6Si_6O_{26}$	…
…	0·006	…	…			$\rho < v$	3·28—3·40	ditto	Mn_2O_3-bearing Zoisit	…
1·756	0·038–0·056	0·024	0·014	b = b, c : a = 3°—5° behind	>180°	$\rho > v$	3·39	ditto	$H_2Ca_4(AlFe)_6Si_6O_{26}$	Twins parallel to 100 not rare.
1·76	0·05	…	…	b = b, c : c = 3°—5° behind	…	…	3·40	ditto	$H_2Ca_4(AlFeMn)_6Si_6O_{26}$	ditto
>1·78	0·032	…	…	b = b, a : a = 30° in front	>180°	…	3·55—3·8	attacked by HCl with difficulty	$H_2(CaFe)_4(Al\ Ce\ Fe)_6Si_6O_{26}$	Twins parallel to 100. Often altered to isotropic substances. According to *Brögger* an orthite from the augite-syenite of Langesund, having a small 2E and —(?) double refraction, gives b = c, c : a (?) = 22°—37½° behind c > b > a from deep brown to pale straw-yellow.
1·7716	0·0122	0·0035	0·0087	b = b, c : a = 2° behind	169°	inclined ρ v	2·93—3·03	soluble in HCl	$\overset{II}{2}(\overset{IV}{R}\ \overset{I}{RO_3})+\overset{I}{R}HO$	Twinning parallel to 100. I (R = Ce, La, Di, Mg, Ca, Fe), IV R = Si, Ti; R = K, Na, H. Almost always intergrown with Fluorite.
great	small	…	…	b = a, c : b = 7½°	not great	horizontal $\rho < v$	3·46	ditto	$\overset{II\ IV}{(R\ RO_3)}+NaF$	Twinning parallel to 100. Almost always intergrown with Fluorite. II R = Ce, La, Di, Y, Fe, Ca IV R = Si, Ti

	Name.	System.	Cleavage. Quality.	Cleavage. Direction.	Cleavage. Angle.	Characteristic Form.	Opt. Char. of the Mineral.	Principal Zone or Face.	Forms of the Principal Zone.	Opt. Char.	Colour.	Pleochroism
	Rosenbuschite	mono-clinic	good, fair	001, 100, $\bar{2}01$	...	rods, needles	−	001 : 100	long lathes	−	light orange	feeble c > b
	Pectolite . .	mono-clinic	good	001, 100	...	rods, needles	+	001 : 100	long lathes	+	colourless	...
	Wollastonite .	mono-clinic	good	001, $00\bar{2}$, 100, $10\bar{1}$	...	rods, needles	−	001 : 100	long lathes	±	colourless	...
Pyroxenes.	Bronzite and Enstatite	rhombic	good, fair	010, 110, 100	88°	short prisms, grains	+	100 : 001	long lathes	±	almost colourless, yellowish	feeble
	Hypersthene .	rhombic	fair	Ditto	...	Ditto	−	Ditto	Ditto	+	greenish, reddish	green, brownis red, reddish yel
	Diaclasite	rhombic	fair	Ditto	...	Ditto	−	...	Ditto	+	yellowish	very feeble
	Diallage .	mono-clinic	good	100, 110	87°	grains, short prisms	+	Ditto	isometric	...	greenish yellowish	variable
	Green Augite . (Diopside, Malacolite, Salite)	mono-clinic	good	110	87°	prisms, grains	+	Ditto	long lathes	...	colourless to greenish	...
	Augite . .	mono-clinic	good	110	87°	short prisms, grains	+	Ditto	broad lathes	...	green, pink, brownish, violet	very variable
	Aegyrine (Acmite)	mono-clinic	good, fair	110, 010	87°	prisms	+(?)	Ditto	long lathes	−	green (brown)	a green (brown b olive to sap gre (pale brown), grass green (greenish yello
	Jadëite .	mono-clinic	good, fair	110, 100	87°	Ditto	+	Ditto	lath-shaped	...	colourless	...
	Triphane .	mono-clinic	good	110, 100	87°	Ditto	+	Ditto	lath-shaped	...	colourless	...
	Wöhlerite . .	mono-clinic	good, fair	010, 100, 110	90°	tabular	−	100	tabular lath-shaped	...	pale yellow	...
	Laavenite . .	mono-clinic	good	100	...	prisms, grains	−	110 : $1\bar{1}0$	lath-shaped	...	yellow	c deep red brow b greenish yello a light wine-yellow

CTING BIAXIAL MINERALS.

Index of Refraction (n) and Double Refraction.				Optic Orientation.	2 E	Dispersion.	Specific Gravity.	Behaviour with Reagents.	Chemical Composition.	Remarks.
$=\frac{\alpha+\beta+\gamma}{3}$	$\gamma-\alpha$	$\beta-\alpha$	$\gamma-\beta$							
high	large	...	...	b=a, c : c= 36° behind	large	...	3·31	easily gelatinizes with HCl	$R_2(SiZrTi)_2O_6$ $Na(FeTiLa)Si_2O_6$	R = Ca, Mn, Na_2, H_2.
1·6	0·038	...	...	b=c, c : a= 6° in front	107°	...	2·8	soluble in HCl with separation of flocculent SiO_2	$(CaNa_2H_2)SiO_3$	Twins parallel to 100.
1·630	0·014	0·012	0·002	b=b, c : a= 38° in front	69°	$\rho > v$	2·8—2·9	easily gelatinizes with HCl	$CaSiO_3$	Twinning parallel to 100.
1·668	0·010	0·005	0·005	c=c, a=a	>180°	$\rho < v$	3·1—3·3	insoluble in HCl	$(MgFe)SiO_3$	Intergrown with diallage. Cleavage-flakes parallel to 010 do not show the locus of an optic axis or bisectrix.
1·70–1·715	0·013	0·010	0·003	Ditto	95°	$\rho > v$	3·5	Ditto	$(FeMg)SiO_3$	Ditto.
...	...	...	...	b=a, c=c	...	$\rho > v$	> 2·8	Ditto	like bronzite, but containing H_2O	Intermediate between bronzite and bastite.
1·688	0·024	0·002	0·022	b=b, c : c= 39° in front	99°	...	3·3	Ditto	$Ca(MgFe)Si_2O_6$ (Al_2O_3)	Intergrown with bronzite. By taking up water, 2 E is apparently reduced. Cleavage-flakes parallel to 100 show the locus of an optic axis.
1·680—1·720	0·030	0·008	0·022	Ditto	112°	...	3·3	Ditto	Ditto	Twinning parallel to 100.
1·715	0·022	...	...	b=b, c : c= 45°–54° in front	70°–103°	...	3·4	Ditto	$Ca(MgFe)Si_2O_6$ $(MgFe)(AlFe)_2SiO_6$	Twinning parallel to 100, more seldom parallel to 001.
1·808	0·052	...	...	b=b, c : a= 3°—5°	...	...	3·5	Ditto	$Na_4Fe_2Si_4O_{12}$	Twinning parallel to 100. Often zonal structure—the outer portion brown, the inner portion green.
1·666 (?)	0·029	...	...	b=b, c : c= 31°–45° in front	...	...	3·3	Ditto	$Na_2Al_2Si_4O_{12}$	Twinning parallel to 100.
1·667	0·016	0·006	0·010	b=b, c : c= 26° in front	101°	...	3·15	Ditto	$Li_2Al_2Si_4O_{12}$	...
1.714	0·026	0·016	0·010	b=c, c : a= 43° behind	176°	strong $\rho < v$	3·41	soluble in HCl with separation of silicic and niobic acids	$(CaNa_2)_{18}Nb_2(SiZr)_{12}O_{42}$	Twinning parallel to 100. Crystallographic position according to *Des Cloizeaux*.
high	large	...	...	b=b, c : a= 21° behind	...	...	3·51	insoluble in HCl	SiO_2=29·63, ZrO_2=28·79 Ta_2O_5=5·20, Fe_2O_3=4·73 Ti_2O_3=2·11, MnO=5·59 CaO=9·70, Na_2O=10·77 H_2O=2·24	...

	Name.	System.	Cleavage. Quality.	Cleavage. Direction.	Cleavage. Angle.	Characteristic Form.	Opt. Char. of the Mineral.	Principal Zone or Face.	Forms Of the Principal Zone.	Opt. Char.	Colour.	Pleochro
Amphiboles.	Antho-phyllite.	rhombic	good	100 110	124°	rods	+	110 : 1$\bar{1}$0	lath-shaped	+	almost colourless	feeble
	Gedrite .	rhombic	ditto	ditto		ditto	—	ditto	ditto	+	ditto	ditto
	Tremolite.	monoclinic	ditto	110	124°30′	ditto	—	ditto	ditto	+	colourless	...
	Actinolite (Smaragdite Nephrite)	monoclinic	ditto	ditto	ditto	ditto	—	ditto	ditto	+	green	feeble in tints, $c >$
	Common Horn-blende	monoclinic	ditto	ditto	ditto	rod-shaped, leafy, granular	—	ditto	ditto	+	green, brownish	strong and $c \geqq b > a$, green, a ye
	Basaltic Horn-blende	monoclinic	ditto	ditto	ditto	ditto	—	ditto	ditto	+	brown	strong in and yellow $c \geqq b > a$
	Arfvedso-nite	monoclinic	ditto	ditto	ditto	prisms	+	ditto	ditto	+	green, bluish green	between g and blui
	Barkevi-cite	monoclinic	ditto	ditto	ditto	ditto	—	ditto	ditto	+	brown	strong in and yell $c > b >$
	Glauco-phane Gastaldite	monoclinic	ditto	ditto	ditto	rod-shaped, leafy	—	ditto	ditto	+	blue	c blue, b violet, a col to yellowis
	Riebeckite	monoclinic	ditto	ditto	ditto	prismatic, fibrous		ditto	ditto	—	blue, green	c green, b a deep bl
	Ainigmatite = Cossyrite	triclinic	good	110 1$\bar{1}$0	...	prisms		110 : 1$\bar{1}$0	lath-shaped		brownish red, coffee brown to opaque	feeble
Micas.	Biotite (Meroxene, Lepidomelane)	monoclinic	good	001	....	leafy, tabular	—	⊥ 001	lath-shaped	+	brown, green, red	strong $c \geqq$
	Anomite .	monoclinic	ditto	ditto	...	ditto	—	ditto	ditto	+	ditto	ditto
	Phlogopite	monoclinic	ditto	ditto	...	ditto	—	ditto	ditto	+	ditto	ditto, but feeble
	Zinnwal-dite Lithionite	monoclinic	ditto	ditto	...	ditto	—	ditto	ditto	+	pale flax-colour greenish white deep red-brown	of variable $c > b >$
	Lepidolite	monoclinic	ditto	ditto	...	ditto	—	ditto	ditto	+	colourless	...
	Muscovite	monoclinic	ditto	ditto	...	ditto	—	ditto	ditto	+	colourless, greenish	...
	Paragonite	monoclinic	ditto	ditto	...	ditto	—	ditto	ditto	+	colourless	...
	Chromium-mica		ditto	ditto	...	ditto	—	ditto	ditto	+	green	...

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				Optic Orientation.	2 E	Dispersion.	Specific Gravity.	Behaviour with Reagents.	Chemical Composition.	Remarks.
			09	0·015	c = c, a = x	177°	ρ < υ	3·15—3·24	insoluble in HCl	$(MgFe)SiO_3$	...
			.	...	ditto	88°	ρ > υ	...	ditto	ditto, but containing Al_2O_3	...
			14	0·014	b = b, c : c = 18° behind	77°	ρ < υ	2·9—3·0	ditto	$CaMg_3Si_4O_{12}$	...
1·628	0·025	0·016		0·009	ditto	77°	ρ > υ	3·02—3·1	ditto	$Ca(MgFe)_3Si_4O_{12}$	...
1·642	0·023	0·012		0·011	b = b, c : c = 12°—22° behind	...	...	3·2—3·3	ditto	ditto, but containing Al_2O_3	Twins parallel to 100.
1·71—1·72	0·072	0·045		0·027	b = b, c : c = 0°—10° behind	>180°	ρ < υ	3·3	ditto	ditto, rich in Fe_2O_3 and Al_2O_3	The double refraction is that given by *Michel Levy* and *Lacroix*; they are maximum values, determined on Bohemian hornblendes. Twinning parallel to 100.
1·70 ?					b = b, c : c (?) = 14° in front	...	...	3·5	ditto	essentially $Na_2Fe_2Si_4O_{12}$	...
1·698	0·021	0·020		0·001	b = b, c : c — 0°—12° behind	...	...	3·5	ditto	ditto	...
1·644	0·022	...		...	b = b, c : c = 5° behind	...	...	3·1	ditto	essentially $Na_2Al_2Si_4O_{12}$	...
...	weak	...		...	b = b, c : x = 5°—7°	large	...	> 3·3	ditto	essentially $Na_2Fe_2Si_4O_{12}$	...
...	...	...		...	extinction-angle on 100 = 30°, on 010 39°, measured to cleavage-cracks	...	...	3·75	insoluble in HCl	approximately like hornblendes rich in iron and soda	Twinning parallel to 010.
...	0·050	...		...	b = b, c : x = 0°—9°	0°—73°	ρ < υ	2·8—3·2	attacked by HCl	$Si_6(AlFe)_6(KH)_6O_{24}$ $Si_6(MgFe)_{12}O_{24}$	Frequent twinning, according to *Tschermak's* law.
...	...	...		...	b = c, c : x = 0°—8°	0°—40°	ρ ≶ υ	ditto	ditto	ditto	ditto
1·584	0·044	...		...	like biotite	0°—30°	ρ < υ	2·75—2·97	ditto	ditto, often containing fluorium	ditto
...	...	...		...	like biotite	0°—65°	ρ > υ	2·82—3·20	ditto	lithium-bearing, rich in iron	ditto
...	...	...		...	b = c, c : x = 0°—2°	50°—70°	ρ > υ	2·76—2·85	not attacked by HCl	$Si_6Al_6(KLi)_6O_{24}$, F-bearing	...
1·592	0·042	0·039		0·003	b = c, c : x = 0°—2°	40°—70°	ρ > υ	2·76—3·1	ditto	$Si_6Al_6K_2H_4O_{24}$	...
1·57 ?	great	...		...	like muscovite	70°	ρ > υ	2·778	ditto	$Si_6Al_6Na_2H_4O_{24}$	...
...	...	...		...	...	...	...	...	...	$Si_6(Al,Cr)_2K_2H_4O_{24}$	...

Name.	System.	Cleavage.			Characteristic Form.	Opt. Char. of the Mineral.	Principal Zone or Face.	Forms of the Principal Zone.	Opt. Char.	Colour.	Pleochroism
		Quality.	Direction.	Angle.							
Margarite . .	mono-clinic	good	001	...	scales, plates	−	⊥ 001	lath-shaped	+	colourless	...
Talc	rhombic	good	001	...	scales, plates	−	⊥ 001	lath-shaped	+	colourless	...
Kaolinite . .	triclinic	good	001	...	scales, plates	−	⊥ 001	lath-shaped	+	colourless	...
Chloritoid group. Chloritoid, Ottrelite, Sismondine, Masonite	mono-clinic	good	001	...	scales, plates	+	⊥ 001	lath-shaped	−	green, blue, seldom colourless	*c* yellowish g *b* plum colou indigo-blu *a* olive-gre
Brandisite, Xanthophyllite	mono-clinic	good	ditto	...	ditto	−	ditto	ditto	+	brownish yellow, yellowish green	moderate to f
Clintonite Seybertite	mono-clinic	good	ditto	...	ditto	−	ditto	ditto	+	ditto	ditto
Astrophyllite	triclinic	good fair	001 010	...	leafy, tabular	+	⊥ 001	lath-shaped	+	yellow	between yello yellowish br
Chlorites. Pennine, Ripidolite	mono-clinic	good	001	...	scales	±	⊥ 001	lath-shaped	±	green	yellowish to dish for ra ⊥ 001, green
Clinochlore	mono-clinic	good	ditto	...	ditto	+	ditto	ditto	−	ditto	ditto
Kämmererite	mono-clinic	good	ditto	...	ditto	+	ditto	ditto	−	peach-blossom to colourless	feeble
Delessite .	(?)	good	ditto	...	ditto, spherocrystals	−	ditto	ditto	+	colourless to greenish yellow	feeble
Serpentines. Serpentine, Chrysotile	rhombic	...	...	...	fibrous	+	110 : 1$\bar{1}$0	fibrous	+	colourless, greenish, yellowish	...
Bastite .	rhombic	good	010	...	tabular, leafy	−	...	...	...	...	...
Antigorite	rhombic	good	010	...	tabular, leafy	−	...	...	...	yellowish	very feebl
Sphene. .	mono-clinic	fair	110	133°52′	prisms, grains	+	...	...	...	colourless, yellowish, reddish	*c* = yellowish *b* = greenish *a* = pale yello
Leucophane .	rhombic (sphen. hem.)	good	010	...	grains	−	...	...	...	colourless	...

FRACTING BIAXIAL MINERALS.

Index of Refraction (n) and Double Refraction.				Optic Orientation.	2 E.	Dispersion.	Specific Gravity.	Behaviour with Reagents.	Chemical Composition.	Remarks.
$n=\frac{\alpha+\beta+\gamma}{3}$	$\gamma-\alpha$	$\beta-\alpha$	$\gamma-\beta$							
1·75	0·009	...	...	b=b, c : a= 9°	10°—70°	$\rho < v$	2·8—3·1	not attacked by HCl	$H_2CaAl_4Si_2O_{12}$	...
1·551	0·04–0·05	...	...	b=c, c=a	10°—20°	$\rho > v$	2·7—2·8	not attacked by HCl	$H_2Mg_3Si_4O_{12}$	...
1·54	strong	...	...	c : a=12°, b=c	...	...	2·34—2·57	dissolved by boiling sulphuric acid	$H_4Al_2Si_2O_{12}$	...
1·72	0·012	...	...	b=b, a : a= 12°—18°	108°	$\rho > v$	3·54	unattacked by acids	$H_2(FeMgMn)Al_2SiO_7$	Twinning according to *Tschermak's* law very common. Zonal structure.
1·654	0·012	...	...	b=b, c : a= 0°—5°	0°—30°	$\rho < v$	3·0—3·1	scarcely attacked by acids	$H_4(CaFeMg)_6(AlFe)_6Si_2O_{21}$	Twinning according to *Tschermak's* law very common.
...	...	...	...	b=c, c : a= 0°—10°	0°—30°	$\rho < v$	3·0—3·1	ditto	...	ditto.
1·704	0·055	0·025	0·030	a nearly normal to 001, b nearly normal to 010	> 180°	...	3·3—3·4	insoluble in acids	$H_8(KNa)_4(FeMn)_9Fe_2Ti_4Si_{13}O_{52}$	Polysynthetic twin-lamellation parallel to 010.
1·577	0·001—0·003	...	...	a or c apparently ⊥ 001	very small	...	2·60—2·96	gelatinizes with HCl	$H_8(MgFe)_5(AlFeCr)_2Si_3O_{18}$	Pseudo-hexagonal.
1·589	0·005—0·011	0·003	0·008	b = b, c makes an angle of 12°—15° with the normal to 001	0°—75°	...	ditto	ditto	ditto	Twinning according to *Tschermak's* law common.
...	feeble	...	...	ditto	...	...	2·62—2·76	ditto	ditto, contains chromium	...
1·619	0·014	...	...	a apparently perpendicular to 001	0°	...	2·89	ditto	ditto, rich in FeO	...
1·54	0·009	...	...	c=c	...	...	2·5—2·7	gelatinizes with acids	$H_4(MgFe)_2Si_2O_9$	...
1·574	small	...	...	c=c, b=a	20°—90°	$\rho > v$	2·6—2·8	ditto	ditto	Cleavage-flakes show the locus of a bisectrix.
1·565	0·011	0·010	0·001	c=c, b=a	20°—90°	nearly 0	2·5	ditto	ditto	ditto.
1·930	0·121	0·006	0·115	b=b, c ⊥ $\bar{1}02$	50°	$\rho > v$	3·3—3·7	not attacked by HCl	$CaSiTiO_5$	Twinning parallel to 001.
1·588	0·027	0·024	0·003	c=c, a=a	74°	$\rho > v$	2·97	...	$6\,NaF + (Be.Ca)_{15}Si_{14}O_{43}$	Intersecting systems of polysynthetic twin-lamellæ frequent.

	Name.	System.	Cleavage.			Characteristic Form.	Opt. Char. of the Mineral.	Principal Zone or Face.	Forms of the Principal Zone.	Opt. Char.	Colour.	Pleochroism.	In $n = \frac{a+}{-}$
			Quality.	Direction.	Angle.								
Felspars.	Orthoclase	mono-clinic	good	001) 010)	90°	prisms, tables, grains	—	001 : 010 110 : 1$\bar{1}$0	lath-shaped, tabular	— ±	colourless	...	1·523—1
	Sanidine .	mono-clinic	ditto	ditto	ditto	ditto	—	ditto	ditto	do.	ditto	...	ditto
	Microcline	triclinic	ditto	ditto	90°20′	ditto	—	ditto	ditto	do.	ditto	...	1·5
	Anortho-clase. .	triclinic	ditto	ditto	ditto	ditto	—	ditto	ditto	do.	ditto	...	1·5
	Albite . .	triclinic	ditto	ditto	93°to 94°	ditto	+	ditto	ditto	do.	ditto	...	1·5
	Oligoclase	triclinic	ditto	ditto	ditto	ditto	—	ditto	ditto	do.	ditto	...	1·5
	Andesine .	triclinic	ditto	ditto	ditto	ditto	—	ditto	ditto	do.	ditto	...	1·5
	Labrado-rite . .	triclinic	ditto	ditto	ditto	ditto	+	ditto	ditto	do.	ditto	...	1·5
	Bytownite	triclinic	ditto	ditto	ditto	ditto	...	ditto	ditto	do.	ditto	...	...
	Anorthite.	triclinic	ditto	ditto	ditto	ditto	—	ditto	ditto	do.	ditto	...	1·5
Zeolites.	Natrolite . (Mesotype)	rhombic	good	110	91°	needles, prisms	+	110 : 1$\bar{1}$0	narrow lathes	+	colourless yellowish	...	1·4
	Scolecite .	mono-clinic	...	...	...	ditto	—	ditto	ditto	—	colourless	...	1·5
	Desmine .	mono-clinic	good	010	...	rods, leaves	—	001 : 010	lath-shaped	—	ditto	...	1·4
	Phillipsite	mono-clinic	ditto	010) 001)	90°	small prisms, needles	+	ditto	ditto	+	ditto	...	1·5
	Harmo-tome .	mono-clinic	ditto	010) 001)	90°	ditto	+	ditto	ditto	±	ditto	...	1·5
	Heulandite (Stilbite)	mono-clinic	ditto	010	...	leafy, tabular	+	001 : 100	lath-shaped tabular	—	ditto	...	1·5
	Epistilbite	mono-clinic	ditto	010	...	prisms	—	110 : 1$\bar{1}$0	lath-shaped	+	ditto	...	1·5
	Brewste-rite . .	mono-clinic	ditto	010	...	prisms	+	ditto	ditto	—	ditto	...	1·4
	Thomso-nite . .	rhombic	ditto	010 100	...	tabular, leafy	+	ditto	ditto	±	ditto	...	1·5
	Laumon-tite . .	mono-clinic	good bad	010 100	...	small prisms	—	ditto	ditto	+	ditto	...	1·5

of Refraction (α) and uble Refraction.			Optic Orientation.	2 E	Dispersion.	Specific Gravity.	Behaviour with Reagents	Chemical Composition.	Remarks.
$\gamma-\alpha$	$\beta-\alpha$	$\gamma-\beta$							
0·007—0·010	0·004	0·003	b = c, a : a = 5° above	125°	$\rho > v$	2·56	insoluble in acids	$(KNa)_2Al_2Si_6O_{16}$	Twins on the Carlsbad type frequent; Baveno and Manebach types rarer.
ditto	ditto	ditto	ditto, or b=b, a : a=5° above	0°—50°	$\rho > v$ $\rho < v$	2·56	ditto	ditto	ditto
ditto	ditto	ditto	a : a in 001 = +15° a : a in 010 = + 5°	130°	$\rho > v$	2·56	ditto	ditto	Intersecting systems of polysynthetic twin-lamellæ almost invariably present.
0·007	0·006	0·001	a : a in 001 = +1½° to 6° a : a in 010 = +6 to 10°	72°—88°	$\rho > v$	2·58—2·60	ditto	$(Na_2K_2Ca)Al_2Si_6O_{16}$	Extremely fine, intersecting twin-lamellæ frequent.
0·008	0·002	0·006	a : a in 001 = + 4° a : a in 010 = + 18°	155°	$\rho < v$	2·62	ditto	$Na_2Al_2Si_6O_{16}$	Twin-lamellation on the Albite and Carlsbad types very common; less frequent on the Pericline and Baveno types.
0·008	0·004	0·004	a : a in 001 = + 1° a : a in 010 = + 4°	...	$\rho < v$	2·64	ditto	Ab_6An_1—Ab_2An_1	ditto
0·008	0·004	0·004	a : a in 001 = — 2½° a : a in 010 = — 9°	...	...	2·65	ditto	Ab_3An_2—Ab_4An_4	ditto
0·008	0·003	0·005	a : a in 001 = — 7° a : a in 010 = — 20°	...	$\rho > v$	2·69	scarcely attacked by HCl	Ab_1An_1—Ab_1An_2	ditto
...	...	...	a : a in 001 = — 25° a : a in 010 = — 33°	...	$\rho > v$	2·71	much attacked by HCl	Ab_1An_3—Ab_1An_6	ditto
0·013	...	...	a : a in 001 = — 37° a : a in 010 = — 36°	...	$\rho > v$	2·75	dissolved by HCl with gelatinization	$Ca_2Al_4Si_4O_{16}$	ditto
0·012	0·003	0·009	c = c, a = a	94°—96°	$\rho < v$	2·17—2·25	gelatinizes with HCl	$Na_2Al_2Si_3O_{10}+5$ aq.	...
0·008	...	...	b = c, c : a = 17°	56°	$\rho < v$	2·2—2·3	ditto	$CaAl_2Si_2O_{10}+4$ aq.	Twinning parallel to 100.
0·006	0·004	0·002	b = b, a : a = 5°—8°	53°	...	2·1—2·2	soluble in HCl with separation of gelatinous SiO_2	$CaAl_2Si_6O_{16}+6$ aq.	Optic anomalies frequent. Twining parallel to 001. Occasionally contains inclusions of micaceous hæmatite.
0·003	...	...	b = a, a : c = 11°—18°	...	$\rho < v$	2·17—2·20	ditto	$(CaK_2)Al_2Si_4O_{12}+4$ aq.	Twins and fourlings.
0·005	0·003	0·002	b = c, a : a = 26°	86°	...	2·45—2·50	soluble in HCl with separation of pulverulent SiO_2	$(BaK_2)Al_2Si_5O_{14}+5$ aq.	ditto.
0·007	0·001	0·006	b = c, a : a = nearly 0°	20°—60°	$\rho < v$	2·18—2·22	soluble in HCl with separation of gelatinous SiO_2	$CaAl_2Si_6O_{16}+5$ aq.	Occasionally contains inclusions of micaceous hæmatite.
0·010	0·008	0·002	b=b, c : c=9° in front	68°	$\rho < v$	2·25		$H_2CaAl_2Si_6O_{17}+4$ aq.	Twinning parallel to 100.
0·012	...	...	b=c, c : a=22° in front	94°	$\rho > v$	2·2—2·4	soluble in HCl	$H_4(SrBaCa)Al_2Si_6O_{18}+3$ aq.	Division into cuneate areas between crossed nicols frequent.
0·027	0·005	0·022	b = c, a = a	83°	$\rho <$	2·31—2·38	soluble in HCl with separation of gelatinous SiO_2	$(CaNa_2)_2Al_2Si_2O_8+5$ aq.	...
0·012	0·010	0·002	b=b, c : c=20° behind	54°	$\rho < v$	2·28—2·41	ditto	$H_4CaAl_2Si_4O_{14}+2$ aq.	Twinning parallel to 100.

Storage